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(54) A process for welding plastics.

(57) Plastics materials can conveniently be welded together by applying an alkylene carbonate (preferably ethylene carbonate or propylene carbonate) to one portion, and then contacting the second portion with the area that had been wetted or softened by the alkylene carbonate.

The alkylene carbonate can be employed either in pure form, or as a mixture with a co-solvent, such as aromatic hydrocarbons, ketones, esters, ethers, glycol ethers, imidazoles tetramethyl urea, N,N'-dimethyl ethylene urea, 1,1,1- trichloroethane, and N-methyl pyrrolidone.

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The invention relates to processes for welding plastics.

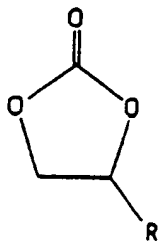
A variety of methods has been used to weld plastics pieces together. One method (see, for example, US-A-4439263) involves heating the edges of two pieces of thermoplastics material, and then forcing the heated portions against one another to form a weld between the two pieces. Another method (see US-A-4457795) involves spinning two rotatable plastic tubes in telescoping relation to one another, whereby the frictional heat generated by rotating one tube relative to the other softens the plastic at the interface, allowing the tubes to weld together when rotation is stopped.

In some applications, it is not desirable or convenient to employ a method requiring heat to form a weld between the pieces of plastic. G A F Corporation's Handbook on N-methyl-2-pyrrolidone (M-PYROL^{R}, N-Methyl-2-Pyrrolidone HANDBOOK, G A F Corporation, Chemical Division, chapter 5, p. 47.) notes that plastics materials may be fused without application of heat by using N-methyl pyrrolidone to etch and soften the surface of the pieces to be joined, followed by pressing the pieces together to form a bond. However, N-methyl pyrrolidone is not an inexpensive solvent, and it would be a significant improvement in the art if a welding agent were available that avoided the need for heat or cements, and yet was economically attractive as well.

We have surprisingly, discovered, that a variety of weldable plastics may be joined using an alkylene carbonate-containing welding agent. Alkylene carbonates are commercially available, present few environmental or health concerns, and are relatively inexpensive. While alkylene carbonates have been used to plasticize certain polymers (see US-A-4775708) they were not known to be effective for welding plastics.

The invention concerns a process for welding plastics, comprising contacting a first piece of weldable plastic with alkylene carbonate; and contacting a second piece of weldable plastic with that point at which the first piece was contacted with alkylene carbonate. In another embodiment of the invention, the welding agent comprises a mixture of the alkylene carbonate and at least co-solvent selected from aromatic hydrocarbons, ketones, esters, ethers, glycol ethers, imidazoles, tetramethyl urea, N, N'-dimethyl ethylene urea, and N-methyl pyrrolidone. Preferred co-solvents include N-methyl pyrrolidone, 1,1, 1-trichloroethane, propylene glycol methyl ether, dibasic ester, methyl iso-amyl ketone, toluene, and hexyl acetate.

Alkylene carbonates useful according to the present invention may be represented by the following formula:



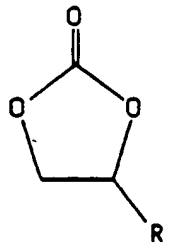
where R is hydrogen or alkyl having 1 to 20 carbon atoms. Preferably R is hydrogen or methyl, i.e. the alkylene carbonate is ethylene carbonate or propylene carbonate. Because propylene carbonate degrades to propylene glycol, a substance of very nominal toxicity, propylene carbonate is preferred. Ethylene carbonate and propylene carbonate are commercially available from Texaco Chemical Co. as Texacar^{R} EC Ethylene Carbonate and Texacar^{R} PC Propylene Carbonate, respectively. Alternatively, a mixture of alkylene carbonates may be used, preferably a mixture of ethylene carbonate and propylene carbonate, such as, Texacar^{R} EC-50.

Solvents that may be used as co-solvents with alkylene carbonates according to the present invention include aromatic hydrocarbons, ketones, esters, ethers, glycol ethers, imidazoles, tetramethyl urea, N,N'-dimethyl ethylene urea, 1,1,1-trichloroethane, and N-methyl pyrrolidone. For example, good results are obtained using formulations containing an alkylene carbonate and one or more of the following solvents: N-methyl pyrrolidone, 1,1,1-trichloroethane, propylene glycol methyl ether, propylene glycol t-butyl ether, propylene glycol butyl ether, dibasic ether, methyl iso-amyl ketone, ethyl lactate, toluene, hexyl acetate, ethylene glycol diacetate, propylene glycol diacetate, and diisobutyl ketone. If a non-alkylene carbonate co-solvent is used with the alkylene carbonate, it is preferred that the non-alkylene carbonate solvent is selected from N-methyl pyrrolidone, 1,1,1-trichloroethane, propylene glycol methyl ether, dibasic ester, methyl iso-amyl ketone, toluene, and hexyl acetate. It is more preferred that the co-solvent is N-methyl pyrrolidone, methyl iso-amyl ketone, toluene, or hexyl acetate. Optionally, other solvents may be added to

Solvent Welding of Plastics with Carbonates and Carbonate-Containing Welding Agents

Ex. No.	Welding Agent Components[1]	PVC	Vinyl	Lexan® GE Polycarbonate	Hi Impact Styrene	Acrylic	Natural ABS
1	EC-50	NW	NW	NW	NW	VGW	VGW
	PC	NW	NW	NW	NW	VGW	VGW
	EC-50/NMP	VGW	GW	VGW	GW	VGW	VGW
	PC/NMP	VGW	VGW	VGW	VGW	VGW	VGW
2	EC-50	NW	NW	NW	NW	VGW	VGW
	PC	NW	NW	NW	NW	VGW	VGW
	EC-50/1,1,1-Trichloroethane	NW	NW	VGW	NW	VGW	VGW
	PC/1,1,1-Trichloroethane	FW	GW	VGW	NW	VGW	VGW
3	EC-50	NW	NW	NW	NW	VGW	VGW
	PC	NW	NW	NW	NW	VGW	VGW
	EC-50/PM	NW	NW	VGW	NW	VGW	VGW
	PC/PM	NW	NW	NW	NW	VGW	VGW
	PM	NW	NW	NW	NW	VGW	NW
4	EC-50	NW	NW	NW	NW	VGW	VGW
	PC	NW	NW	NW	NW	VGW	VGW
	EC-50/PTB	NW	NW	NW	NW	VGW	VGW
	PC/PTB	NW	NW	NW	NW	VGW	VGW
	PTB	NW	NW	NW	NW	NW	NW
5	EC-50	NW	NW	NW	NW	VGW	VGW
	PC	NW	NW	NW	NW	VGW	VGW
	EC-50/DBE	NW	NW	VGW	NW	VGW	VGW
	PC/DBE	NW	NW	VGW	NW	VGW	VGW
	DBE	NW	NW	VGW	VGW	VGW	VGW
6	EC-50	NW	NW	NW	NW	VGW	VGW
	PC	NW	NW	NW	NW	VGW	VGW
	EC-50/MIAK	VGW	GW	VGW	GW	VGW	VGW
	PC/MIAK	VGW	GW	VGW	GW	VGW	VGW
	MIAK	VGW	VGW	NW	VGW	VGW	VGW

(1) Co-solvents were blended in a 1:1 weight ratio.
NW = No weld; FW = Fair weld; GW = Good weld; and VGW = Very good weld.
PVC = Polyvinyl chloride; ABS = Acrylonitrile butadiene styrene; EC = Texacar® Ethylene carbonate; PC = Texacar® Propylene carbonate; EC-50 = 50/50 by weight blend of Texacar® EC and PC; DBE = Dibasic ester (Du Pont); MIAK = Methyl iso-amyl ketone; PM = Propylene glycol methyl ether; NMP = N-methyl pyrrolidone; and PTB = Propylene glycol t-butyl ether.



wherein R is hydrogen or alkyl having 1 to 20 carbon atoms.

3. A process according to Claim 1 or 2 characterized in that the alkylene carbonate is propylene carbonate.

4. A process according to Claim 1 or 2 characterized in that the alkylene carbonate is ethylene carbonate.

5. A process according to Claim 1 or 2 characterized in that the alkylene carbonate is a mixture of propylene carbonate and ethylene carbonate.

6. A process according to any one of Claims 1 to 5 characterized in that the weldable plastic is an acrylic or acrylonitrile/butadiene/styrene polymer.

7. A process according to any one of claims 1 to 5 characterized in that the alkylene carbonate solvent is used in admixture with at least one co-solvent selected from aromatic hydrocarbons, ketones, esters, ethers, glycol ethers, imidazoles tetramethyl urea, N,N'-dimethyl ethylene urea, 1,1,1- trichloroethane, and N-methyl pyrrolidone.

8. A process according to Claim 7 characterized in that the co-solvent is N-methyl pyrrolidone, 1,1,1-trichloroethane, propylene glycol methyl ether, propylene glycol t-butyl ether, propylene glycol butyl ether, dibasic ester, methyl iso-amyl ketone, ethyl lactate, toluene, hexyl acetate, ethylene glycol diacetate, propylene glycol diacetate, or diisobutyl ketone.

9. A process according to Claim 7 or 8 characterized in that the weldable plastic is a vinyl chloride, vinyl, polycarbonate, styrene, acrylic, or acrylonitrile/butadiene/styrene polymer.